HIGH-RESOLUTION SATELLITE-DERIVED WIND FIELDS
PE 0602435 (035-71)

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LONG-TERM GOALS:

Accurately determine the three dimensional global atmospheric wind fields via satellite remote sensing data for both real time analyses and input to numerical weather prediction models.

OBJECTIVES:

Develop techniques to map the three-dimensional (3-D) wind fields associated with severe weather systems, using tropical cyclones for the initial study. Use remotely sensed data to determine the wind field from the surface to the upper levels to better understand the storm structure and to assist in determining the storm's intensity, thereby providing an important link to tropical cyclone data assimilation efforts.

APPROACH:

Remotely sensed digital data from multiple satellite platforms are being utilized to augment the historically sparse *in situ* meteorological observations over the ocean. Tropical oceans, in particular, contain only a few island stations and fewer shipping lanes than the mid-latitudes, but experience some of the world's most severe storms and an increasing amount of Naval activity.

The geostationary platforms operated by the U.S. (GOES-8,9) Japan (GMS-5), and Europe (METEOSAT-6) are the primary tools available to monitor tropical cyclones. Cloud-tracked winds (CTW) derived from sequential visible and/or infrared (vis/IR) imagery have been routinely created for over 15 years and mainly support *coarse* resolution global analysis/forecast efforts. This project will develop innovative high-density produce cloud-tracked winds and take full advantage of the satellite spatial resolutions of 1-5 km and temporal sampling of 15-60 minutes.

The main CTW limitation is the fact that cloud targets must exist during the entire imagery sequence. This obstacle has been largely overcome in the upper-levels by applying similar methodologies to the water vapor (WV) channel data. WV tracked winds (WVTW) occur within the 150-450 mb layer and DO NOT require the presence of clouds, but simply a suitable gradient within the moisture field. Thus, WV winds have the potential of filling the data void in cloud-free areas as well as producing winds in the presence of clouds and very high moisture regions.

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This geostationary derived wind data set is being supplemented with surface wind speed measurements from the Special Sensor Microwave/Imager (SSM/I), which covers a 1400 km swath. This 25 km resolution passive microwave derived surface data is also combined with ocean surface wind vectors from the active microwave ERS-1,2 scatterometers in order to define the surface wind field. These scatterometers provide a 500 km swath of wind vectors at a resolution of 25-50 km and augment the SSM/I wind speeds with crucial wind directional information. In addition, the NASA scatterometer (NSCAT) and its two 600 km swaths will be used during its operational life from summer 96 to spring 97.

WORK COMPLETED:

Algorithms to produce high quality, cloud- and water vapor-tracked winds using GOES-8, GOES-9 and GMS-5 data has been successfully tested and run for the last 9-18 months. Satellite derived winds have been compared with over 40,000 radiosonde winds for the western and eastern Pacific and the Atlantic basins. A corresponding 6.4 work unit has transitioned the initial capabilities and provides JTWC/NLMOC with near real-time cloud and water vapor-tracked winds via Gif images and ingest to the Navy Operational Global Atmospheric Prediction System (NOGAPS). A digital data set with over 900 cases containing SSM/I surface wind speeds coincident with tropical cyclones has been processed.

ERS-1,2 scatterometer wind data for 1992-1997 has been accessed and is being collocated with SSM/I winds within a 6.4 developed data fusion software module. NSCAT surface wind vectors for the full time of operation are online at NRL-MRY and being integrated with the data sets noted above.

TECHNICAL RESULTS:

High density, low-level cloud-tracked winds have been produced from both GOES-8, GOES-9 and GMS-5 for tropical cyclones. Comparisons with operational cloud-tracked winds indicate a substantial improvement in defining the 3-D wind field has been achieved (Velden, 1997). *Asymmetries* in the tropical cyclone inflow have been documented by tracking cumulus clouds at the full spatial and temporal sensitivity of the geostationary sensors. These winds have assisted in defining the radius of surface gale-force winds and have been successfully used experimentally by JTWC. Comparisons with scatterometer winds on the periphery of storms has been very positive.

Water vapor-tracked winds have readily shown their value to map upper-level synoptic and mesoscale features that directly impact storm tracks by turning many hurricanes northward into the central Atlantic and shearing others apart (especially evident in 1997 season). Height assignment errors are 40-50 mb, while wind speed RMS errors are 3-6 ms^{-1} (partially speed dependent errors over the range 10-100 ms^{-1}), based on over 40,000 matchups with radiosondes throughout the Pacific and Atlantic basins. Input from analysts has been very positive and data assimilation impact studies with atmospheric models have shown 10-15% improvement in 72 hour track forecasts with NOGAPS, as noted by 6.4 efforts (Velden, et. al., 1997; Goerss, et. al., 1998). Additional recent studies confirm early published findings.

Water-vapor wind quality control has been improved by better height assignments. The effort is still hindered in part by the model first guess fields, which typically lack the mesoscale detail revealed by the actual storm conditions. Thus, efforts are underway with the Coupled Ocean Atmospheric Mesoscale Prediction System (COAMPS) to study the impact the WV winds may have on a mesoscale model. COAMPS should provide more realistic 1st guess fields from which the cloud and WVTW algorithms would benefit.

SSM/I surface wind speeds have shown value in defining the radius of gale-force winds, but are often stymied by the inability to produce retrievals in rain and high water vapor regions. This limitation is largely solved by using scatterometer winds. Scatterometer wind vectors have proven valuable in permitting the analyst to detect when a system develops a “closed” circulation. This permits the analyst to upgrade a disturbance to a depression or tropical storm based on the wind speeds and is a crucial step in the warning process (Hawkins and Helveston, 1997).

NSCAT data has shown that the two 600 km swaths increased the surface wind vectors by more than a factor of two over that achieved by ERS-2. The revisit times for tropical cyclones was dramatically reduced and each TC was typically sampled once/day. NSCAT wind speeds typically exceeded the 25 ms^{-1} maximum experienced with ERS-2 data and were in excess of 30 ms^{-1} in many cases. These higher winds were a direct result of the 25 km footprint on NSCAT versus the 50-60 km cells for ERS-1,2. Coincident visible, infrared and SSM/I data indicate that NSCAT did encounter rain attenuation in heavy rainbands as expected. These winds must be flagged and used with caution. NRL-MRY efforts to map synoptic rainrates via a combination of SSM/I-IR data may prove useful for this purpose and we are working cooperatively with the Jet Propulsion Lab’s calibration/validation team.

IMPACT:

The expanded and new data sets described in this effort have a direct impact on the Navy’s ability to monitor tropical cyclones around the globe, particularly for the Joint Typhoon Warning Center (JTWC), which has responsibility for issuing storm warnings throughout the entire western Pacific and Indian Oceans, and the Naval Atlantic Meteorology and Oceanography Center (NLMOC) in Norfolk, which covers the Atlantic basin storms. These wind data sets have explained storm track and intensity changes that otherwise would have only been postulated or discovered after the fact. Responses from these Naval units has been extremely positive.

TRANSITIONS:

The basic algorithms from this 6.2 effort have been successfully transitioned to the SPAWAR 6.4 work unit noted below. Near real-time low-level cloud and upper-level water vapor winds are being created with both GMS-5 and GOES-8 data and were available to both JTWC and NLMOC during the last two storm seasons. These winds were provided to each organization via the Internet in the form of graphics images with wind vectors superimposed on visible or water vapor imagery. In addition, the validation of the winds with radiosondes proved that they were superior to current operational winds from NOAA/NESDIS, and FNMOC began using the new winds from this transitioned effort in late July, 1996 for assimilation into NOGAPS. Efforts are well underway to transition the algorithms to operational regional sites.

RELATED PROJECTS:

This project is closely related to a corresponding 6.4 effort sponsored by the Space and Naval Warfare Systems Command (SPAWAR PMW-185) entitled "Multi-Sensor Atmospheric Applications", funded under PE 0603207N. The 6.4 project serves as the transition vehicle, works closely with JTWC and NLMOC, and currently has taken the software partially developed in this 6.2 task and produced near real time operational demonstration wind data sets for large oceanic domains. Feedback from both JTWC and NLMOC has been extremely positive.

The NRL 6.2 project entitled "Improved Severe Storm Characterization" is also related due to its focus on extracting tropical cyclone intensity information from both visible/infrared imagery as well as newer applications with passive microwave imagery from the SSM/I. This neural network based approach of analyzing SSM/I 85 GHZ imagery blends well with the 3-D wind field mapping effort, since understanding the environmental winds is crucial to forecasting storm intensity changes.

REFERENCES:

Velden, C.S., 1997, Update on high-density satellite-derived multispectral winds produced by UW-CIMSS over the tropics, 22nd AMS Conf. on Hurricanes and Tropical Meteorology, pp. 35-36.

Velden, C.S., C.M. Hayden, S. Nieman, W.P. Menzel, S. Wanzong and J. Goerss, 1997, Upper-tropospheric winds derived from geostationary satellite water vapor observations, Bull. Amer. Meteor. Soc., 78, pp. 173-195.

Goerss, J., C.S. Velden and J.D. Hawkins, 1997, The impact of multi-spectral GOES-8 wind information on Atlantic track forecasts in 1995. Part 2: NOGAPS forecasts, Accepted in Mon. Wea. Rev. (Feb issue).

Hawkins, J.D. and M. Helveston, 1997, Tropical cyclone wind information from ERS-1,2 and NASA scatterometers, 22nd AMS Conf. on Hurricane and Tropical Meteorology, pp. 55-56.